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manual # 3

VHF Slotted Line with Measuring Head

Type LMM BN 3916

ROHDE & SCHWARZ · MÜNCHEN

Rot.5114

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Instruction Book

VHF Slotted Line with Measuring Head

Type LMM BN 3916

80 to 300 mc

Rot.5114
555

Supplement to Instruction Book
(Rot. 5114/555)

VHF Slotted Line with Measuring Head

Type LMM BN 3916

Subject: Characteristic Impedance of 50 Ohm or 75 Ohm

The specifications given for the 60-Ohm slotted line with respect to frequency range, usable length, VSWR, accuracy, etc. also apply to the slotted lines BN 3916/50 and BN 3916/75 having a characteristic impedance of 50 Ohm or 75 Ohm, respectively.

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1 Specifications

Slotted Line

Frequency range	80 to 300 mc
Characteristic impedance	60 Ω ± 0.3 Ω
Usable length	1930 mm
Residual VSWR	1.03
Calibration	permits reading to ± 1 mm
Terminals, either end	R&S short-stroke connector Dezifix B (FS 432/60)
Dimensions	65 mm dia. x 2200 mm

Measuring Head

Tuning range	80 to 300 mc
in 5 bands	80 to 105, 140, 185, 240, 300 mc
Probe coupling	capacitive

Indicator

Calibration . . . . . in terms of VSWR E_{max}/E_{min} and E_{min}/E_{max}

R-f voltage requirement in case of termination in the characteristic impedance . . . . . approx. 2 v

Total weight . . . . . 28 lbs.

2 Purpose and Application

The Slotted Line Type LMM permits impedances to be measured with respect to their resistive and reactive components. Its frequency range extends from 80 to 300 mc (4.25 to 1 m).

If the familiar special measuring methods are used, the slotted line lends itself also to measuring the attenuation of cables, the insertion loss and transfer constant of four-terminal networks. Furthermore transmission line adapters can accurately be adjusted for their nominal characteristic impedance.

3 Function and Construction

The slotted line is a coaxial precision tubing having a characteristic impedance of 60 Ω and a slotted outer conductor for sampling the voltage distribution on the line. The inner conductor is held by calite supports. To prevent that the phase velocity in the slotted line differs considerably from the one in an ideal coaxial line, the ceramic supports of the inner conductor have been proportioned in a manner as to ensure the necessary rigidity in normal operation. The phase velocity is somewhat lower than it would be in an ideal case, the difference being about 0.5 %. The correction factor for standing waves is hence 0.955. This fact must be borne in mind where accurate measurements are desired; the l value read must be multiplied by 1.005 if one wants to obtain the l value in the vacuum, for in obtaining the quotient l/λ, λ is mostly assumed to be the wave-

length in the vacuum. If, however, it is the wavelength of the operating frequency on the slotted line that is to be determined, it is unnecessary—for l as well as for λ—to multiply by the factor 1.005 since it is cancelled when the quotient is obtained.

Either end of the slotted line is equipped with an R&S short-stroke connector Dezifix B for connection of the signal generator and the unknown.

For indication of the maxima and minima developed on the slotted line under the influence of an incident and a reflected wave, the field inside the line is sampled with a capacitive probe. The r-f signal is then applied to a parallel resonant circuit tunable for the respective test frequency and rectified by a germanium diode, the rectified current being indicated by a moving-coil meter. The probe projecting into the interior of the line through its slot mounts on the carriage movable along the entire length of the line. The depth to which the probe penetrates is variable so far that the coupling can be adjusted by about 10 %. Down to one end of the slotted line, the rectified current is tapped from a rail with sliding contact and thence flows to the meter through a flexible cable. Consequently, the movement of the carriage is not obstructed by the cable.

The scale of the meter is calibrated directly in terms of the VSWR, both for $S = E_{max}/E_{min}$ (= 1 to 6) and for $S = E_{min}/E_{max}$ (= 1 to 0.2). This is necessary because the various transmission line charts used for evaluation do not give a uniform definition of the VSWR.

4 Operating Instructions

4.1 Putting into Operation

The slotted line and the measuring head together with the indicator are shipped in separate containers.

Before these components are assembled, it is first necessary to remove the stop screw at the left end of the slotted line (underside). Subsequently slide the measuring head (without probe!) carefully onto the slotted line, screw the probe into the measuring head from above, plug the cable of the indicator into the jacks at the r.h. foot of the slotted line and replace the left stop screw. Furthermore, clean the guideways of the carriage from dust, if necessary, and apply a slight film of grease.

Now connect the unknown to the left end of the slotted line and the signal generator to the right end. The r-f voltage requirement is about 2 v. For a generator, we recommend to use our Power Signal Generator Type SMLM BN 4105.

4.2 Measuring S and 1

First tune the measuring head for the desired test frequency and then move the measuring head from the left stop towards the right until the first voltage maximum is reached. Now vary the r-f signal from the generator until the indicator reads exactly "1" (full-scale deflection). For a fine adjustment of this deflection, the degree of coupling can be varied at the probe.

Now move the measuring head on—without disturbing the adjustment of the other controls—until a voltage minimum is reached. This should be the first minimum as viewed from the end of the unknown. The indicator will then give a direct reading of the VSWR $S = E_{max}/E_{min}$ or $S = E_{min}/E_{max}$, while the scale on the line permits direct reading of the l value in millimeters. Here l is the length from the probe to the flange of the l.h. short-stroke connector. Any connection beyond this point can be considered part of the unknown.

For the impedance measurement by means of the slotted line it is principally two transmission line charts that have found acceptance for the evaluation: the O. Schmidt chart (Fig. 1) and the P.H. Smith chart (Fig. 2). Both charts are referred to 1 Ω so that the values of the resistive and reactive components as determined by means of the chart are to be multiplied by the characteristic impedance ($Z_o = 60\ \Omega$) of the slotted line.

4.21 Evaluation by Means of the O. Schmidt Chart

The chart (Fig. 1) is formed by the right-angled co-ordinates for the resistive component R/Z_o and the reactive component X/Z_o and by the two circle families for the values $S = E_{max}/E_{min}$ and l/λ.

The S circles lie about the point $R/Z_o = 1$ on the abscissa. Each S circle is significant for a certain standing-wave ratio E_{max}/E_{min}. This is greater the more the unknown impedance $Z_x = R + jX$ differs from the characteristic impedance Z_o of the slotted line. The l/λ circles pass through the point $R/Z_o = 1$ and intersect all S circles at right angles.

The measurement of S and $1/\lambda$ unambiguously determines a point by which R and jX are established. If, for instance, S is found to be 2 and $1/\lambda = 0.4$, one draws a perpendicular to the abscissa from the intersection of the two circles and another to the ordinate. Thus one obtains $R/Z_o = 0.67$ on the abscissa and $X/Z_o = 0.48$ on the ordinate. Hence the unknown impedance is

$$Z_x = 0.67 \cdot Z_o + j0.48 \cdot Z_o = 40.2\ \Omega + j28.8\ \Omega$$

4.22 Evaluation by Means of the P.H. Smith Chart

In this chart, the loci for $1/\lambda$ are rays outgoing from the center $R/Z_o = 1$ while the loci for S are concentric circles whose centers lie at $R/Z_o = 1$.

In the evaluation, e.g. for $1/\lambda = 0.40$ and S = 0.25, a line is drawn from the center to the value 0.40 on the outer scale of the chart while, with a pair of compasses, an S arc is drawn from the point 0.25 of the real axis to the $1/\lambda$ line. This intersection determines unambiguously the resistive component $R/Z_o = 0.37$ referred to 1 Ω and the reactive component $jX/Z_o = 0.67$. The unknown impedance is thus

$$Z_x = 0.37 \cdot Z_o + j0.67 \cdot Z_o = 22.2\ \Omega + j40.2\ \Omega$$

4.23 Double-Minimum Method

The so-called double minimum method is used to measure the resistive component in case of a relatively large reactive component, that is to say, in case of a very large standing-wave ratio S.

To do so, a sensitive galvanometer on which only the values 0.707 and 1 must be calibrated is to be connected in place of the indicator. This calibration can be done, for instance, with the aid of the standing wave by adjusting for the value 1 if the probe is on the voltage maximum. The value 0.707 lies then at the left or right by $l = \lambda/8$. The voltage distribution in the region of the minimum is shown in Fig. 3. The voltage standing-wave ratio is obtained from

$$S = \frac{2\pi \Delta l}{\lambda} \quad \text{or from} \quad S = \frac{\lambda}{2\pi \Delta l}$$

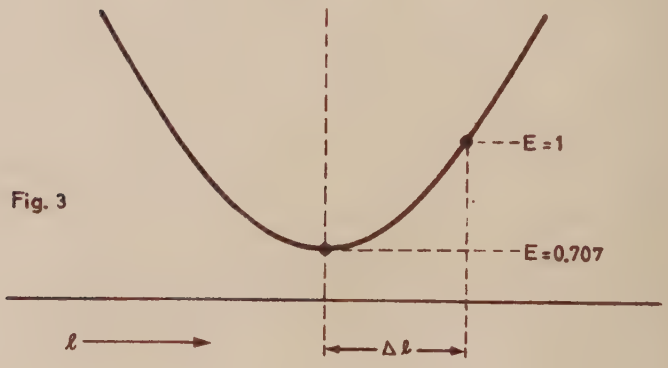

Fig. 3

5 Maintenance

Under normal operating conditions the slotted line, together with the measuring head and indicator, does not require any particular maintenance. It is, however, recommended to clean the guideways of the carriage time and again and to apply a film of grease.

Because of the ceramic supports of the inner conductor, the slotted line should not be exposed to heavy shocks. For this reason, it is also necessary to use always the original packing for transportation of the slotted line.

Care should also be taken to ensure that the adjusting screws of the inner conductor are not tampered with by unskilled personnel. Where it is necessary to readjust these screws, a frequency of about 100 to 200 kc should be applied to the slotted line. In this case connect the probe of the measuring head—through a shielded cable—with a sensitive r-f amplifier and adjust the inner conductor until the voltage remains constant when the carriage is pushed back and forth.

For the accuracy of the adjustment of the inner conductor including the guideway of the carriage a value of 1.03 is guaranteed within the frequency range 80 to 300 mc. Generally, however, the deviation from 1 of the ratio between various maxima is not greater than 1 to 2 %.

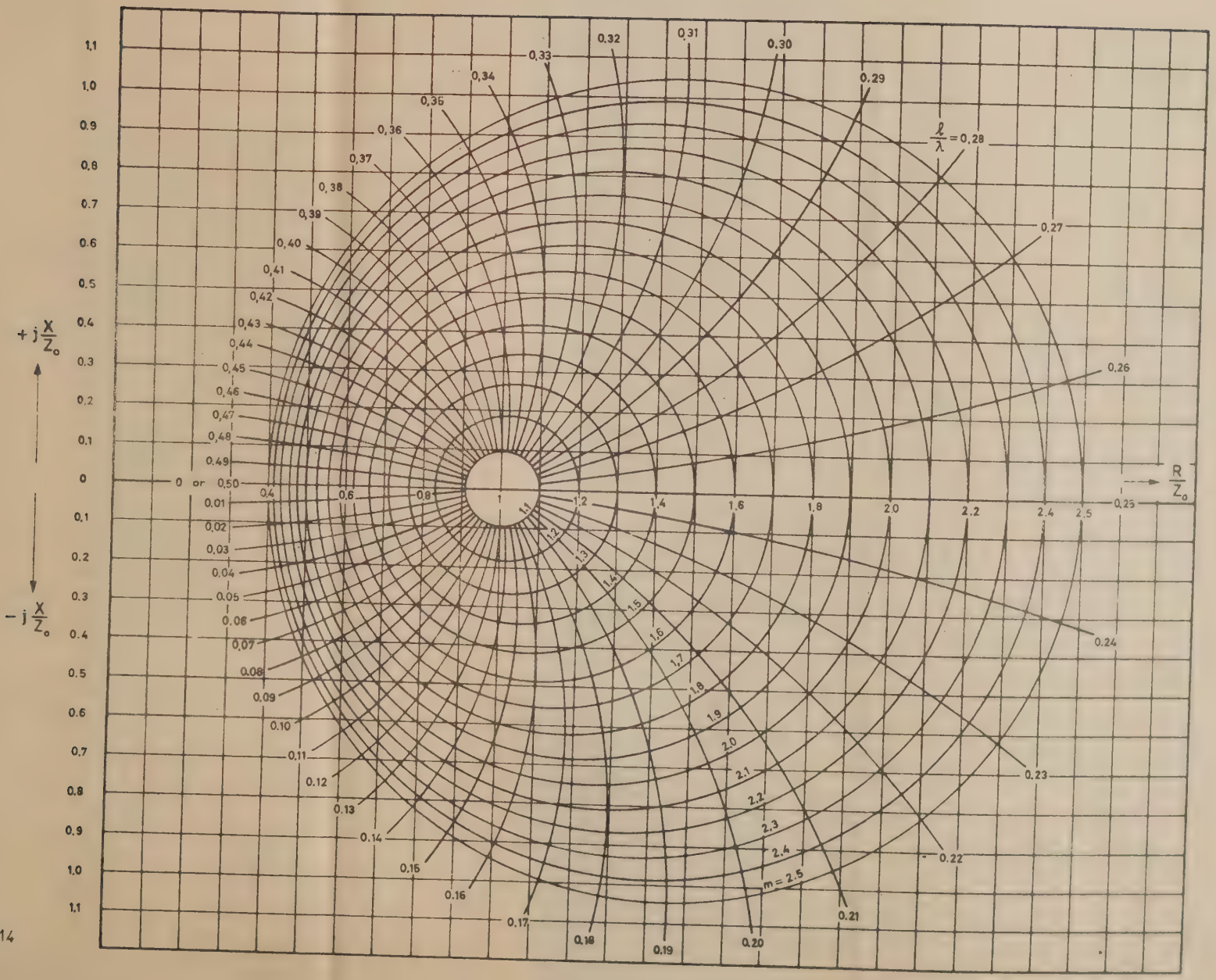

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Fig.1 Q Schmidt Chart

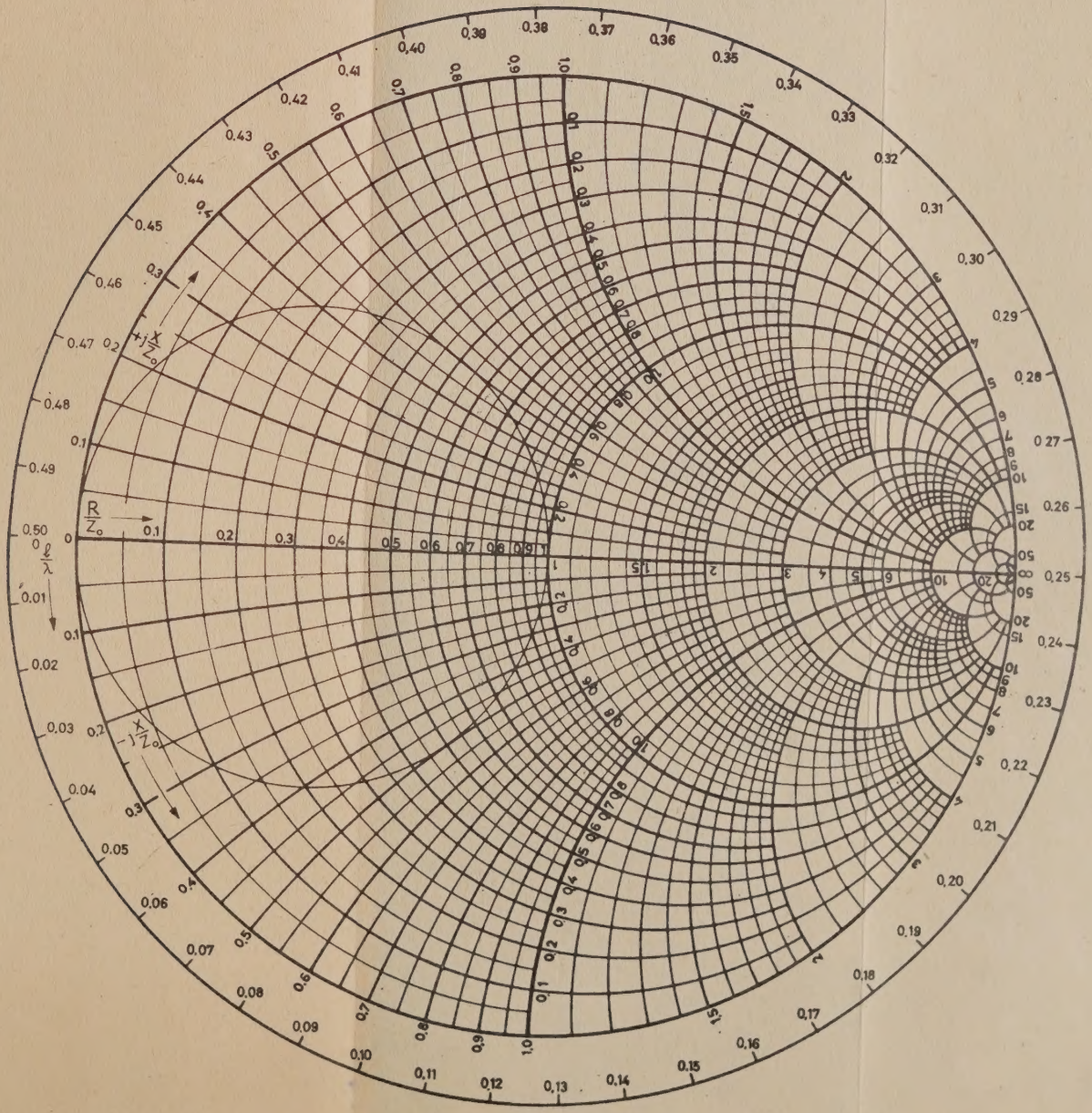

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Fig. 2 P.H. Smith Chart

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